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(54) **OSCILLATOR**

(75) Inventors: **Yasuharu Onishi**, Kanagawa (JP); **Jun Kuroda**, Kanagawa (JP); **Yuichiro Kishinami**, Kanagawa (JP); **Shigeo Satou**, Kanagawa (JP); **Yukio Murata**, Kanagawa (JP); **Nobuhiro Kawashima**, Kanagawa (JP); **Tatsuya Uchikawa**, Kanagawa (JP); **Motoyoshi Komoda**, Kanagawa (JP)

(73) Assignee: **NEC CASIO MOBILE COMMUNICATIONS, LTD.**, Kanagawa (JP)

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PCT Pub. Date: **Oct. 4, 2012**

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(51) **Int. Cl.**

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H04R 17/00	(2006.01)
B06B 1/06	(2006.01)
G10K 9/122	(2006.01)

(52) **U.S. Cl.**
CPC ***H03B 28/00*** (2013.01); ***B06B 1/06*** (2013.01); ***G10K 9/122*** (2013.01); ***H04R 17/00*** (2013.01); *H04R 2217/03* (2013.01); *H04R 2499/11* (2013.01)

(58) **Field of Classification Search**
CPC H03B 28/00
USPC .... 310/313 R, 348; 331/107 R, 116 R, 331/116 M, 154
See application file for complete search history.

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Primary Examiner — Joseph Chang
Assistant Examiner — Jeffrey Shin
(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(57) **ABSTRACT**

Provided is an oscillator including a piezoelectric vibrator (**10**), a vibration member (**20**) that constrains the piezoelectric vibrator (**10**) on one surface thereof, an elastic member (**40**) that is provided on one surface of the vibration member (**20**) or the other surface opposite to one surface and provided so as to be located between edges of the piezoelectric vibrator (**10**) and the vibration member (**20**) when seen in a plan view, a fixing member (**42**) that is provided on one surface or the other surface of the vibration member (**20**) and provided so as to be located between the piezoelectric vibrator (**10**) and the elastic member (**40**) when seen in a plan view, and a supporting member (**30**) that supports the vibration member (**20**) through the elastic member (**40**) and the fixing member (**42**).

6 Claims, 5 Drawing Sheets

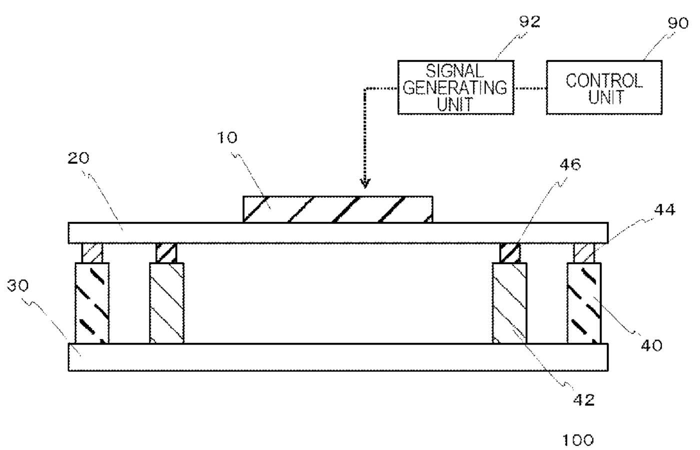

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FIG. 1

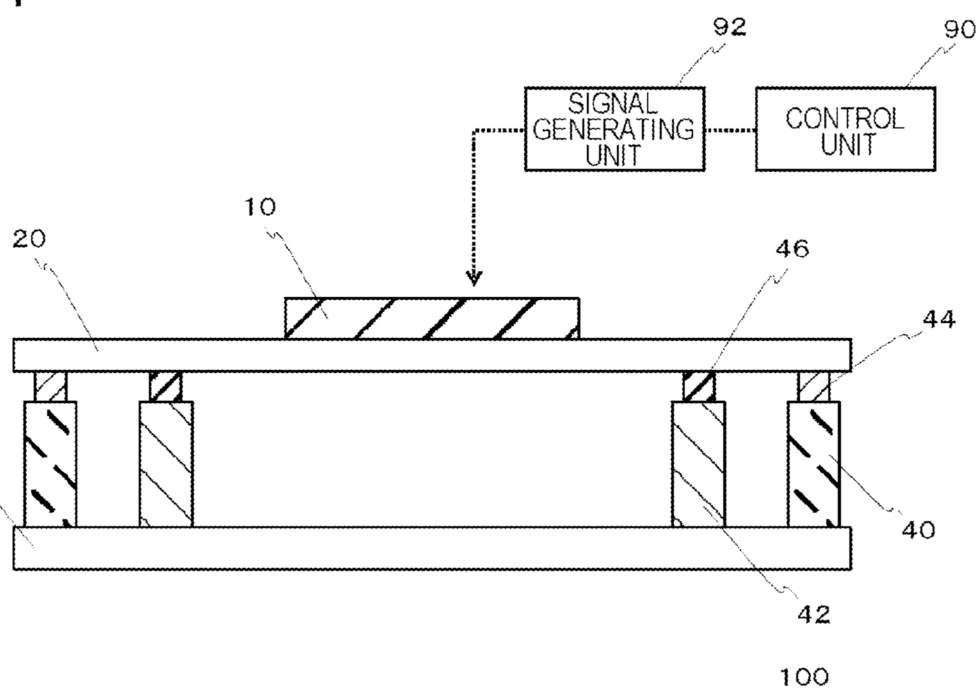

92
90
SIGNAL GENERATING UNIT
CONTROL UNIT
10
20
46
44
30
40
42
100

FIG. 2

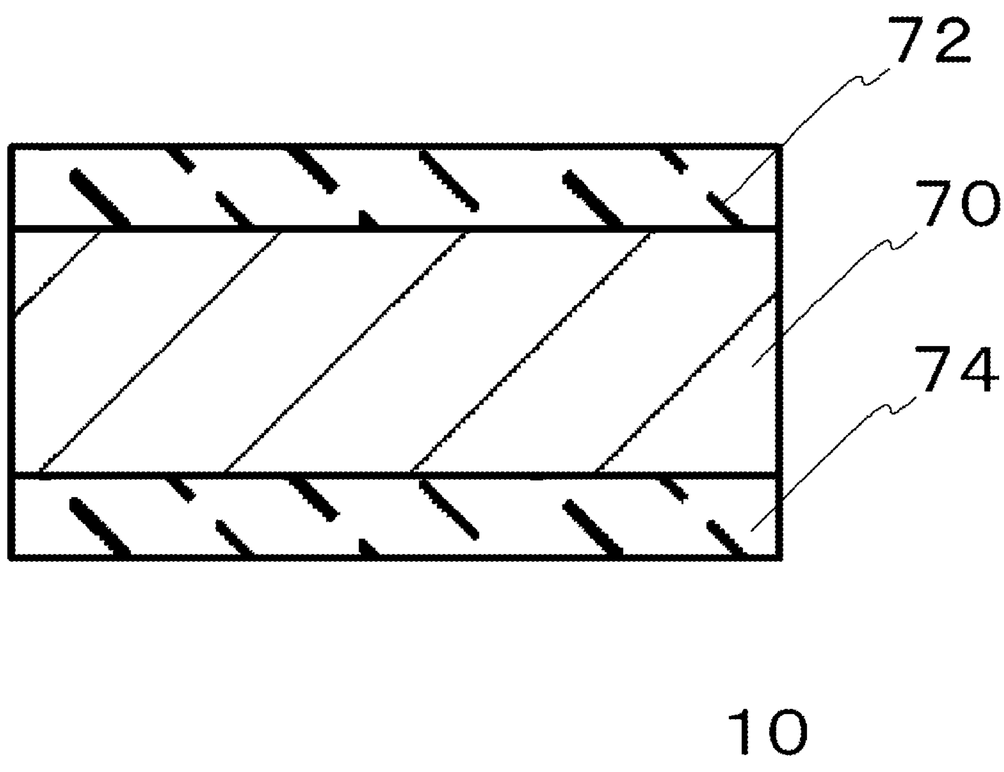


FIG. 3

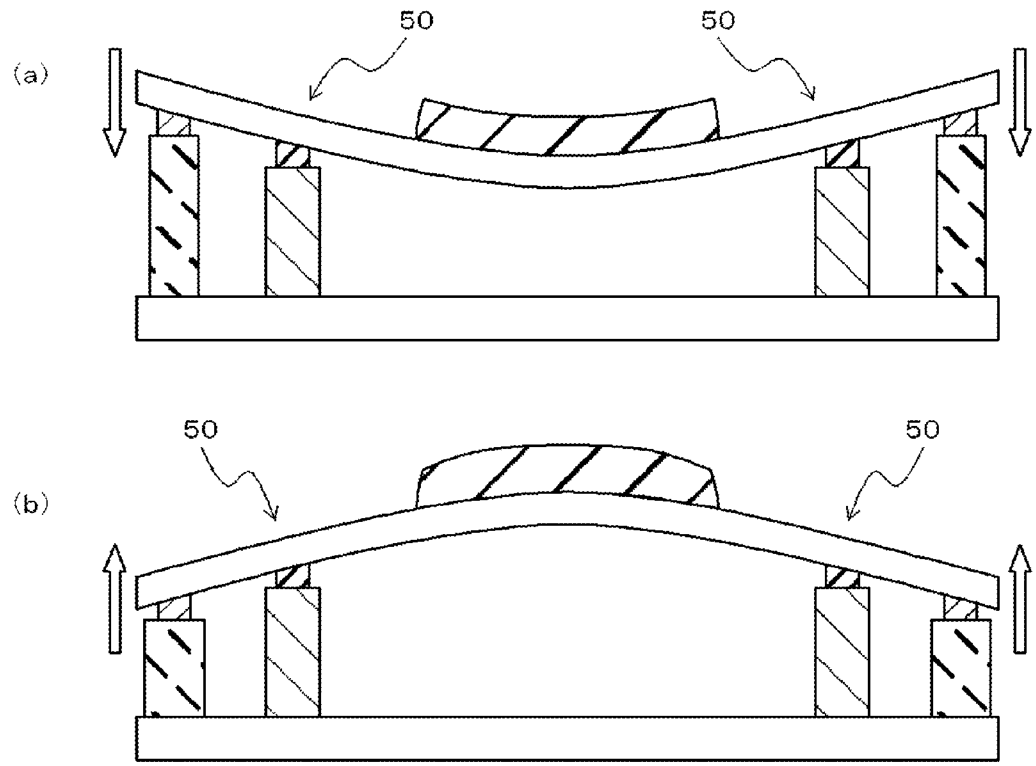


FIG. 4

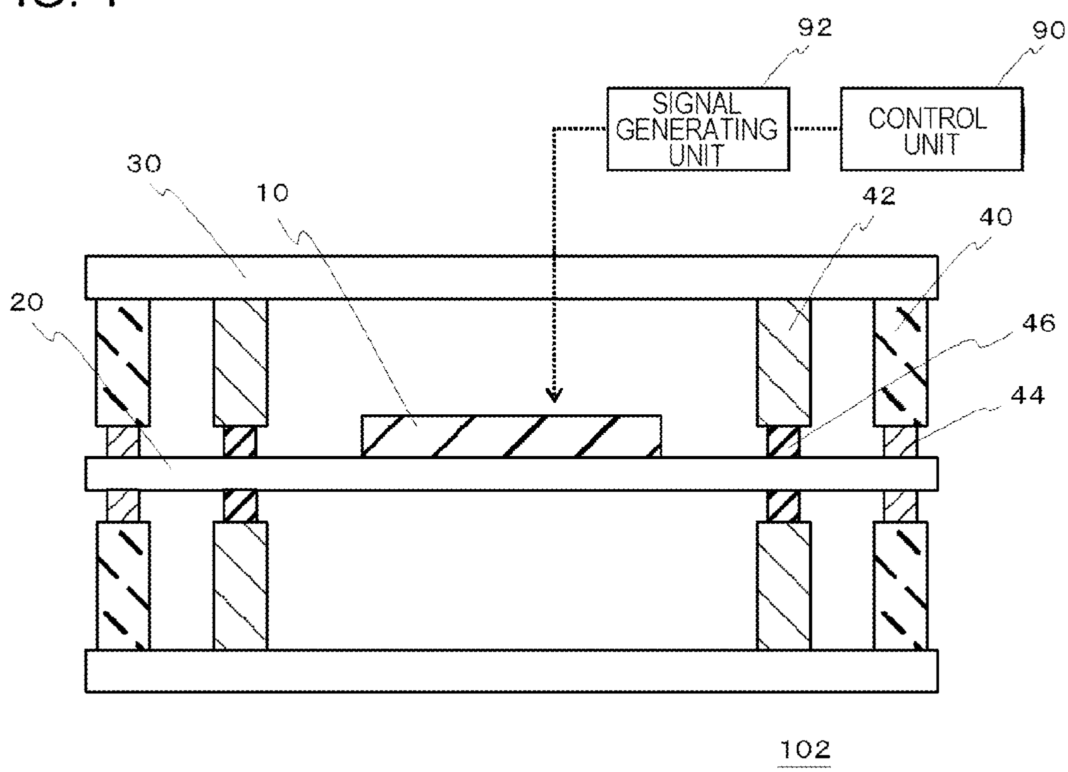
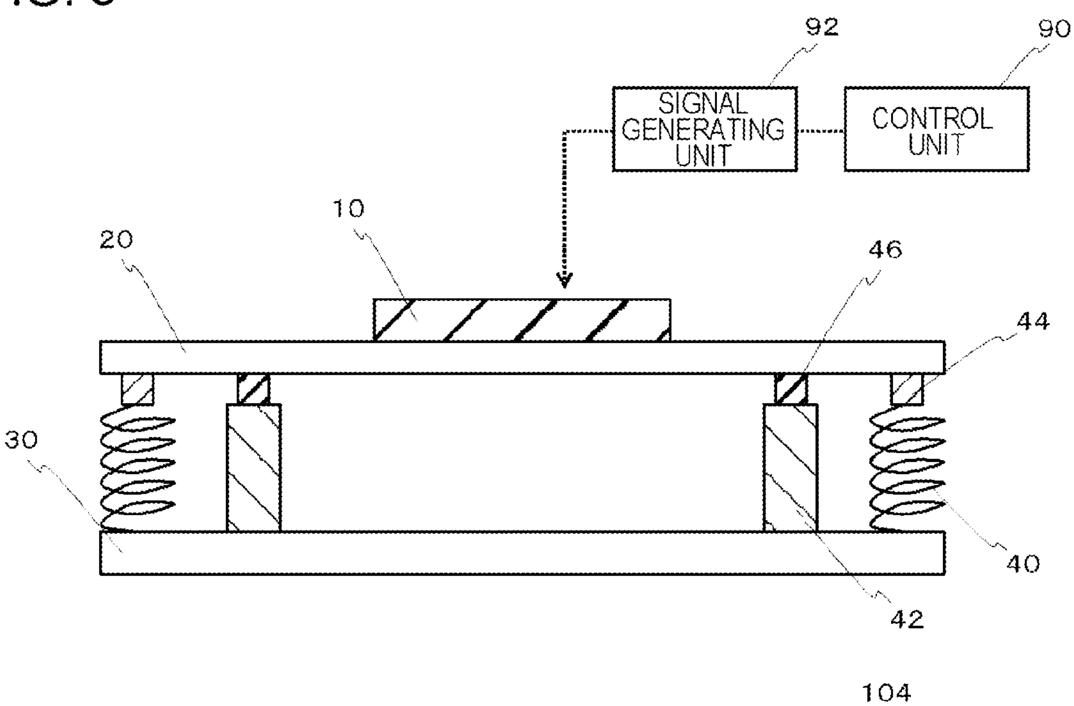

92
90
SIGNAL GENERATING UNIT
CONTROL UNIT
30
10
42
40
20
46
44
102

FIG. 5



92
90
SIGNAL GENERATING UNIT
CONTROL UNIT
10
20
46
44
30
40
42
104

OSCILLATOR

CROSS REFERENCE TO RELATED APPLICATIONS

This is a National Stage of International Application No. PCT/JP2012/001605, filed Mar. 8, 2012, claiming priority from Japanese Patent Application No. 2011-081036, filed Mar. 31, 2011, the contents of all of which are incorporated herein by reference in their entirety.

TECHNICAL FIELD

The present invention relates to an oscillator having a piezoelectric vibrator.

BACKGROUND ART

As an electro-acoustic transducer used in an electronic device, there is a piezoelectric electro-acoustic transducer using a piezoelectric vibrator. The piezoelectric electro-acoustic transducer generates a vibrational amplitude by using an expansion and contraction motion of the piezoelectric vibrator. Thus, there is an advantage in a reduction in the thickness thereof as compared with an electrodynamic electro-acoustic transducer constituted by a magnet, a voice coil, or the like. A technique involved in the piezoelectric electro-acoustic transducer is disclosed in, for example, Patent Document 1. In the technique disclosed in Patent Document 1, a base to which a piezoelectric element is attached is connected to a supporting member through a vibrating film having a lower rigidity than the base.

In addition, the piezoelectric vibrator is also used as, for example, an ultrasound wave sensor. A technique disclosed in Patent Document 2 relates to the ultrasound wave sensor using the piezoelectric vibrator, and discloses that an outer circumferential edge of a metal plate that vibrates flexurally in association with an expansion and contraction vibration of a piezoelectric member is held by a holding member.

RELATED DOCUMENT

Patent Document

[Patent Document 1] Pamphlet of International Publication WO. 2007/083497

[Patent Document 2] Japanese Unexamined Patent Publication No. 2007-251271

DISCLOSURE OF THE INVENTION

In an oscillator using a piezoelectric vibrator, it is required to improve a sound pressure level thereof.

According to the invention, provided is an oscillator comprising: a piezoelectric vibrator; a vibration member that constrains the piezoelectric vibrator on one surface thereof; an elastic member that is provided on one surface of the vibration member or the other surface opposite to one surface and provided so as to be located between the piezoelectric vibrator and an edge of the vibration member when seen in a plan view; a fixing member that is provided on one surface or the other surface of the vibration member and provided so as to be located between the piezoelectric vibrator and the elastic member when seen in a plan view; and a supporting member that supports the vibration member through the elastic member and the fixing member.

According to the invention, in an oscillator using a piezoelectric vibrator, it is possible to improve a sound pressure level thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned objects, other objects, features and advantages will be made clearer from preferred embodiments described below, and the following accompanying drawings.

FIG. **1** is a cross-sectional view illustrating an oscillator according to a first embodiment.

FIG. **2** is a cross-sectional view illustrating a piezoelectric vibrator shown in FIG. **1**.

FIG. **3** is a cross-sectional view illustrating a vibration mode of the oscillator shown in FIG. **1**.

FIG. **4** is a cross-sectional view illustrating an oscillator according to a second embodiment.

FIG. **5** is a cross-sectional view illustrating an oscillator according to a third embodiment.

DESCRIPTION OF EMBODIMENTS

Hereinafter, embodiments of the invention will be described with reference to the accompanying drawings. In all the drawings, like elements are referenced by like reference numerals and descriptions thereof will not be repeated.

FIG. **1** is a cross-sectional view illustrating an oscillator **100** according to a first embodiment. The oscillator **100** comprises a piezoelectric vibrator **10**, a vibration member **20**, an elastic member **40**, a fixing member **42**, and a supporting member **30**. For example, the oscillator **100** is installed in a portable terminal device such as a cellular phone.

The vibration member **20** constrains the piezoelectric vibrator **10** on one surface thereof. The elastic member **40** is provided on the other surface opposite to one surface of the vibration member **20** and provided so as to be located between the piezoelectric vibrator **10** and the edge of the vibration member **20** when seen in a plan view. The fixing member **42** is provided on the other surface of the vibration member **20** and provided so as to be located between the piezoelectric vibrator **10** and the elastic member **40** when seen in a plan view. The supporting member **30** supports the vibration member **20** through the elastic member **40** and the fixing member **42**. Hereinafter, the configuration of the oscillator **100** will be described in detail.

The vibration member **20** has, for example, a flat plate shape. The vibration member **20** is constituted by a metal material, for example, a versatile material such as phosphor bronze or stainless steel. The thickness of the vibration member **20** is preferably 5 μm to 500 μm. In addition, a modulus of longitudinal elasticity of the vibration member **20** is preferably 1 GPa to 500 GPa. When the modulus of longitudinal elasticity of the vibration member **20** is excessively low or high, there is a concern that vibration characteristics and reliability of the oscillator may be damaged.

The elastic member **40** is constituted by a resin material such as an olefin-based polymer material, for example, polyethylene terephthalate or urethane. For example, a plurality of the elastic members **40** are provided around the piezoelectric vibrator **10** so as to be separated from each other, but the invention is not limited thereto. In other words, the elastic members **40** may be provided as one body so as to surround the entire circumference of the piezoelectric vibrator **10**, or only one elastic member may be provided in a portion of the perimeter of the elastic member **40**.

In addition, in the embodiment, the elastic member **40** is provided so as to be bonded to the other surface of the vibration member **20**, but may be provided so as to be bonded to, for example, one surface of the vibration member **20**.

The fixing member **42** is constituted by a metal material, for example, brass, stainless steel, or copper. The fixing member **42** has a higher elastic modulus than the elastic member **40**.

For example, the fixing member **42** is located on a straight line connecting the elastic member **40** and the center point of the piezoelectric vibrator **10**. Thus, in a vibration mode of the embodiment, which will be described later, it is possible to effectively increase a vibrational amplitude of the vibration member **20**.

In a similar manner as the elastic member **40**, for example, a plurality of the fixing members **42** are provided around the piezoelectric vibrator **10** so as to be separated from each other, but the invention is not limited thereto. In addition, in the embodiment, the fixing member **42** is provided so as to be bonded to the other surface of the vibration member **20**, but may be provided so as to be bonded to, for example, one surface of the vibration member **20**.

As illustrated in FIG. **1**, the fixing members **42** are bonded to the vibration member **20** through, for example, a connection member **46**. The connection member **46** may be constituted by, for example, a metal material. The connection member **46** may be constituted by an elastic material, for example, natural rubber, NBR rubber, or silicon rubber. In this case, since constraint force from the fixing member **42** with respect to the vibration member **20** is mitigated, it is possible to increase the vibrational amplitude in the vibration mode of the embodiment which will be described later.

In a plane direction horizontal to one surface of the vibration member **20**, the cross section of the connection member **46** is smaller than that of the fixing member **42**. Even in this case, since constraint force from the fixing member **42** with respect to the vibration member **20** is mitigated, it is possible to increase the vibrational amplitude in the vibration mode of the embodiment which will be described later.

As illustrated in FIG. **1**, the elastic member **40** is bonded to the vibration member **20** through, for example, a connection member **44**. The connection member **44** is constituted by, for example, a metal material.

As illustrated in FIG. **1**, the supporting member **30** is disposed on the other surface side of the vibration member **20**. The supporting member **30** disposed on the other surface side of the vibration member **20** is bonded to the elastic members **40** and the fixing members **42** that are provided on the other surface of the vibration member **20**. Thus, the supporting member **30** supports the vibration member **20**.

In addition, for example, when the elastic member **40** and the fixing member **42** are provided on different surfaces of the vibration member **20**, the supporting member **30** is disposed on one surface side and the other surface side of the vibration member **20** (not shown).

FIG. **2** is a cross-sectional view illustrating the piezoelectric vibrator **10** shown in FIG. **1**. As illustrated in FIG. **2**, the piezoelectric vibrator **10** has a piezoelectric body **70**, an upper electrode **72**, and a lower electrode **74**. The piezoelectric body **70** is interposed between the upper electrode **72** and the lower electrode **74**. In addition, the piezoelectric body **70** is polarized in the thickness direction thereof (vertical direction of FIG. **2**). The piezoelectric vibrator **10** is, for example, circular or elliptical in a plane direction horizontal to one surface of the vibration member **20**.

The piezoelectric body **70** is constituted by a material having a piezoelectric effect, and is constituted by, for example, lead zirconate titanate (PZT) or barium titanate ($BaTiO3$) as a material having a high electro-mechanical conversion efficiency. In addition, the thickness of the piezoelectric body **70** is preferably 10 μm to 1 mm. When the thickness is less than 10 μm, there is a concern that the piezoelectric body may be damaged during handling because the piezoelectric body **70** is constituted by a brittle material. On the other hand, when the thickness exceeds 1 mm, the electric field intensity of the piezoelectric body **70** decreases, which results in a decrease in the energy conversion efficiency.

The upper electrode **72** and the lower electrode **74** are constituted by a material having an electrical conduction property, for example, silver or a silver/palladium alloy. Since silver is a low-resistance versatile material, there is an advantage from the viewpoint of a manufacturing cost and a manufacturing process. In addition, a silver/palladium alloy is a low-resistance material having an excellent oxidation resistance and has an excellent reliability. The thicknesses of the upper electrode **72** and the lower electrode **74** are preferably 1 μm to 50 μm. When the thicknesses are less than 1 μm, it is difficult to uniformly mold the upper electrode **72** and the lower electrode **74**. On the other hand, when the thicknesses exceed 50 μm, the upper electrode **72** or the lower electrode **74** serves as a constraint surface with respect to the piezoelectric body **70**, which results in a decrease in the energy conversion efficiency.

The oscillator **100** includes a control unit **90** and a signal generating unit **92**. The signal generating unit **92** is connected to the piezoelectric vibrator **10** and generates an electrical signal to be input to the piezoelectric vibrator **10**. The control unit **90** is connected to the signal generating unit **92** and controls the generation of a signal by the signal generating unit **92**. The control unit **90** controls the generation of the signal by the signal generating unit **92** based on information that is input from the outside, thereby allowing the output of the oscillator **100** to be controlled.

When the oscillator **100** is used as a parametric speaker, the control unit **90** inputs a modulated signal of the parametric speaker through the signal generating unit **92**. In this case, the piezoelectric vibrator **10** uses a sound wave of equal to or more than 20 kHz, for example, 100 kHz, as a carrier wave of the signal.

In addition, when the oscillator **100** is used as a general speaker, the control unit **90** may directly input a sound signal to the piezoelectric vibrator **10** through the signal generating unit **92**.

In addition, when the oscillator **100** is used as a sound wave sensor, a signal to be input to the control unit **90** is a command signal to the effect that the sound wave is oscillated. When the oscillator **100** is used as the sound wave sensor, the signal generating unit **92** causes the piezoelectric vibrator **10** to generate a sound wave having a resonance frequency of the piezoelectric vibrator **10**.

An operational principle of the parametric speaker is as follows. The parametric speaker performs sound reproduction using a principle in which ultrasound waves on which an AM modulation, a DSB modulation, an SSB modulation, or an FM modulation is performed are emitted into the air and an audible sound is issued based on the non-linear characteristics when ultrasonic waves are propagated into the air. The term "non-linear" herein indicates a transition from a laminar flow to a turbulent flow when the Reynolds number expressed by the ratio of the inertial action and the viscous action of a flow increases. In other words, since the sound wave is very slightly disturbed within a fluid, the sound wave is propagated non-linearly. In particular, when the ultrasound waves are emitted into the air, higher harmonic waves associated with the non-linearity are conspicuously generated. In addition, the sound wave is in a sparse and dense state in which molecular assemblies in the air are mixed lightly and shadily. When it takes time for air molecules to be restored rather than compressed, the air which is not capable of being restored after the compression collides with air molecules continuously propagated, and thus a shock wave occurs. The audible sound is generated by this shock wave. Since the parametric speaker can form a sound field only in the vicinity of a user, and the parametric speaker is excellent from the viewpoint of privacy protection.

Next, a principle in which the amplitude of the vibration member **20** increases in the embodiment will be described. FIG. **3** is a cross-sectional view illustrating a vibration mode of the oscillator **100** shown in FIG. **1**. The vibration member **20** vibrates in a vertical direction of FIG. **3** in association with an expansion and contraction vibration of the piezoelectric vibrator **10**. At this time, the vibration member **20** vibrates using the fixing member **42** as a supporting point **50**.

In the embodiment, the elastic member **40** is provided at a position closer to the edge of the vibration member **20** than the fixing member **42**. For this reason, when the vibration member **20** vibrates, stress from the elastic member **40** is applied to the end of the vibration member **20** in the directions shown by block arrows of FIG. **3**.

In other words, as illustrated in FIG. **3**(*a*), when the vibration member **20** vibrates in a convex manner downward in the drawing, a portion closer to the edge of the vibration member **20** than the supporting point **50** is displaced upward in the drawing. At this time, downward stress in the drawing, that is, stress in a direction in which the vibration of the vibration member **20** increases is applied to the end of the vibration member **20** from the elastic member **40**.

In addition, as illustrated in FIG. **3**(*b*), when the vibration member **20** vibrates in a convex manner upward in the drawing, a portion closer to the edge of the vibration member **20** than the supporting point **50** is displaced downward in the drawing. At this time, upward stress in the drawing, that is, stress in a direction in which the vibration of the vibration member **20** increases is applied to the end of the vibration member **20** from the elastic member **40**.

In this manner, the amplitude of the vibration member **20** increases.

Next, effects of the embodiment will be described. The oscillator **100** according to the embodiment comprises the elastic member **40** that is provided on the other surface of the vibration member **20** and provided so as to be located between the piezoelectric vibrator **10** and the edge of the vibration member **20** when seen in a plan view, and the fixing member **42** that is provided on the other surface of the piezoelectric vibrator **10** and provided so as to be located between the piezoelectric vibrator **10** and the elastic member **40** when seen in a plan view. The vibration member **20** is supported by the supporting member **30** through the elastic members **40** and the fixing members **42**.

With such a configuration, when the vibration member **20** vibrates, the vibration member **20** receives stress in the vertical direction from the elastic member **40** by using the fixing member **42** as a supporting point. Thus, the amplitude of the vibration member **20** increases. Therefore, in the oscillator using the piezoelectric vibrator, it is possible to improve a sound pressure level thereof.

FIG. **4** is a cross-sectional view illustrating an oscillator **102** according to a second embodiment, and corresponds to FIG. **1** according to the first embodiment. The oscillator **102** according to the embodiment has the same configuration as the oscillator **100** according to the first embodiment except that the elastic members **40** and the fixing members **42** are provided on one surface and the other surface of the vibration member **20**.

As illustrated in FIG. **4**, the elastic members **40** are bonded to the vibration member **20** through the connection member **44** on one surface and the other surface of the vibration member **20**. The elastic member **40** provided on one surface of the vibration member **20** and the elastic member **40** provided on the other surface thereof are located so as to overlap each other when seen in a plan view.

The fixing members **42** are bonded to the vibration member **20** through the connection member **46** on one surface and the other surface of the vibration member **20**. The fixing member **42** provided on one surface of the vibration member **20** and the fixing member **42** provided on the other surface of the vibration member **20** are located so as to overlap each other when seen in a plan view.

The supporting members **30** are disposed on one surface side and the other surface side of the vibration member **20**. The supporting members **30** support the vibration member **20** through the elastic members **40** and the fixing members **42** that are provided on one surface and the other surface of the vibration member **20**.

Even in the embodiment, it is possible to obtain the same effects as the first embodiment.

In addition, the elastic members **40** are provided on one surface and the other surface of the vibration member **20**.

For this reason, when the vibration member **20** vibrates, stress applied from the elastic members **40** to the vibration member **20** increases as compared with the first embodiment. Thus, it is possible to further increase the amplitude of the vibration member.

FIG. **5** is a cross-sectional view illustrating an oscillator **104** according to a third embodiment, and corresponds to FIG. **1** according to the first embodiment. The oscillator **104** according to the embodiment has the same configuration as the oscillator **100** according to the first embodiment except that the elastic member **40** is constituted by a spring.

Even in the embodiment, it is possible to obtain the same effects as the first embodiment.

As described above, although the embodiments of the invention have been set forth with reference to the drawings, they are merely illustrative of the invention, and various configurations other than stated above can be adopted.

The application claims priority from Japanese Patent Application No. 2011-081036 filed on Mar. 31, 2011, the content of which is incorporated herein by reference in its entirety.

The invention claimed is:

1. An oscillator comprising:

a piezoelectric vibrator;

a vibration member that constrains the piezoelectric vibrator on one surface thereof;

an elastic member that is provided on one surface of the vibration member or another surface, opposite the one surface, and provided so as to be located between the piezoelectric vibrator and an edge of the vibration member when seen in a plan view;

a fixing member that is provided on one surface or the other surface of the vibration member and provided so as to be located between the piezoelectric vibrator and the elastic member when seen in a plan view; and

a supporting member that supports the vibration member through the elastic member and the fixing member,

wherein the elastic member and the fixing member are provided on a first region of the vibration member, another elastic member and another fixing member are provided on a second region of the vibration member, and

the first and second regions oppose one another across the piezoelectric vibrator in the plan view.

2. The oscillator according to claim 1, wherein the elastic member is constituted by polyethylene terephthalate or urethane.

3. The oscillator according to claim 1, wherein the elastic member is a spring.

4. The oscillator according to claim 1,

wherein the elastic member and the another elastic member are respectively provided on the one surface and another surface, opposite the one surface, of the vibration member.

5. The oscillator according to claim 1,

wherein the fixing member is bonded to the vibration member through an elastic material.

6. An oscillator comprising:

a piezoelectric vibrator;

a vibration member that constrains the piezoelectric vibrator on one surface thereof;

a single elastic member, comprising one body including a first elastic portion and a second elastic portion, on one surface of the vibration member and on another surface, opposite the one surface, and

the first elastic portion is provided so as to be located between the piezoelectric vibrator and an edge of the vibration member when seen in a plan view;

a fixing member that is provided on one surface or the other surface of the vibration member and provided so as to be located between the piezoelectric vibrator and the single elastic member when seen in a plan view; and

a supporting member that supports the vibration member through the first elastic portion and the fixing member,

wherein the first elastic portion and the fixing member are provided on a first region of the vibration member,

the second elastic portion and another fixing member are provided on a second region of the vibration member, and

the first and second regions oppose one another across the piezoelectric vibrator in the plan view.

* * * * *